Evidence for the use of post-operative physiotherapy after surgical repair of the cranial cruciate ligament in dogs

Abstract

Physiotherapy is well utilised and evidenced in human practice. However, the use of physiotherapy in veterinary practice is a relatively new concept with much of the current treatment based on human evidence. Currently the evidence base for the use of physiotherapy in dogs in the post-operative period after surgery for ruptured cranial cruciate ligament (CCL) is minimal. Published evidence does indicate that the use of cold therapy in the immediate post-operative period can result in reduced swelling, reduced pain and increased range of motion (ROM). Additionally, post-operative physiotherapy programmes were shown to improve ROM, muscle mass and limb use post operatively when compared with a restricted exercise programme. However, there are some inconsistencies in results, which may in part be due to experiment design — data collection methods and sample numbers. More research is required in this field of veterinary medicine to provide evidence that the benefits of post-operative physiotherapy, widely recognised in human medicine, are truly applicable to the canine patient.

Key words: cranial cruciate ligament, physiotherapy, post-operative care, evidence-based practice, rehabilitation

Physiotherapy has long been used in human medicine with vast amounts of research published as to its benefits. However, the use of physiotherapy in veterinary practice is a relatively new concept and the evidence base for such treatments is in its infancy. Rupture of the cranial cruciate ligament (CCL) is common in the dog and in most cases treatment of the condition requires surgical intervention to stabilise the stifle (McKee and Cook, 2006). Post-operative care of the canine patient after surgical repair of the CCL previously centred on bandaging the limb for a couple of weeks, followed by 6–12 weeks of limited exercise (Fossum et al, 1997). However, it has since been recognised that the changes that occur to musculoskeletal tissue during immobilisation and disuse can result in delayed recovery (Millis, 2004a) (*Figure 1*). Early post-operative physiotherapy is now advocated. This review will look at the evidence available to support this recommendation.

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Physiotherapy techniques advocated

Cryotherapy

Cryotherapy is the application of cold to tissues for therapeutic purposes and results in vasoconstriction, with subsequent reduced blood flow, and reduced nerve conduction velocity (Steiss and Levine, 2005). Consequently, cryotherapy helps to reduce inflammation and swelling and reduce pain post operatively or after exercise (Shumway, 2007; Saunders, 2007). It is also suggested that cryotherapy can help to improve range of motion post operatively due to reduction in inflammation and pain (Steiss and Levine, 2005). Cryotherapy may be achieved using ice packs wrapped in a thin layer of material and placed on the limb (Shumway, 2007) or with the use of a cold compression unit; combining cryotherapy with compression which improves contact with the limb (Rexing et al, 2010). The use of cryotherapy in the post-operative period is well documented although there are no clear guidelines for duration or frequency of treatments. Precaution should be taken though as excessive cooling can be detrimental to tissues. *Table 1* shows some of the protocols suggested in veterinary texts.

Heat therapy

Heat therapy has the opposite effect of cold therapy; inducing vasodilation and subsequent increased blood flow to the area. This affect, although detrimental if initiated in the acute inflammatory phase as it encourages oedema/swelling, is beneficial in later stages of healing (Heinrichs, 2004). Increased blood flow to injured tissues results in accelerated healing and also limits the activity of pain receptors resulting in reduced pain. It is also believed that stimulation of the thermal receptors in the skin blocks the trans-

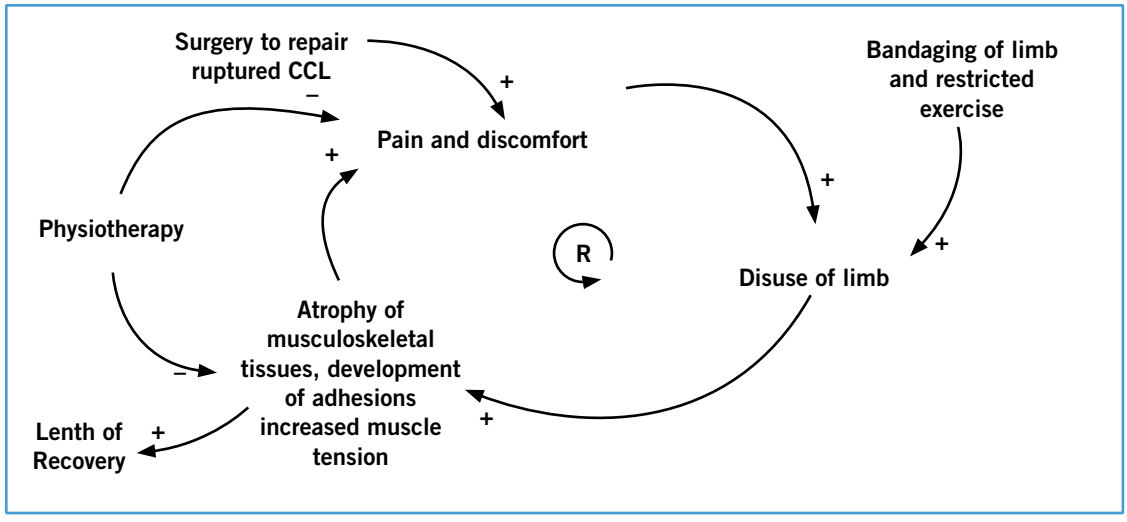

Figure 1. Casual loop diagram of the post-operative recovery process after surgical repair of the cranial cruciate ligament (CCL). '+' indicates a positive/reinforcing relationship; as one factor increase/decreases so does the other. '–' indicates a negative relationship; as one factor increases the other decreases and vice versa. 'R' indicates a reinforcing loop.

mission of pain signals, further improving analgesia (Heinrichs, 2004). Heating tissues also increases tissue elasticity (Steiss and Levine, 2005) and can result in improved range of motion through decreased stiffness in the joint capsule and increased muscle and tendon elasticity. The application of heat can therefore be beneficial prior to exercise/physiotherapy. Superficial heating of the skin can be achieved by using hot pack/wraps, whirlpool baths, electric heat pads or infrared lamps (Steiss and Levine, 2005). In the post-operative patient whirlpool baths would be contraindicated due to the surgical wound, and Steiss and Levine (2005) suggest burns are a greater risk with electric heat pads and infrared lamps. Therefore a hot pack/wrap would be the most appropriate option. As with cryotherapy there are no clear guidelines for the duration and frequency of treatment. Steiss and Levine (2005) and Sharp (2010) suggest application for 15–30 minutes but give no guidance for how often treatment could be applied. Excessive heating

Table 1. Suggested cryotherapy protocols

Protocol suggested	Reference
15–20 minutes, immediately after surgery and 2–4 times daily thereafter	Shumway (2007)
20 minutes, 3–6 times daily.	Millis (2006)
10–15 minutes, frequency not suggested	Gear and Mathie (2011)

Table 2. Massage techniques and how they are performed

Technique		How to perform	Purpose
Stroking		The hands are gently glided over the body in any direction (usually head to tail), minimal pressure is applied	Relaxes the patient and accustoms them to handling
Effleurage		With gentle to medium pressure the hands are glided over the body in the direction of the heart/ from distal to proximal	Relaxation Encourages lymphatic and venous return
Petrissage	Kneading	Inward and upward pressure is applied intermittently to tissues	Creates a pumping action to increase blood flow to the area and removal of waste Helps to mobilise soft tissues
	Skin rolling	The skin and subcutaneous tissues are lifted up using the thumb and fingers. The skin is then rolled between the thumb and fingers	Helps mobilise tissues
	Wringing	The tissue is grasped and raised up with both hands. The hands are then moved back and forth in opposite directions before the tissue is gently released	Improves circulation Helps mobilise and stretch tissues

(Shumway, 2007; Sharp, 2010)

of tissues can be detrimental so caution should be employed.

Massage

Massage is the process of applying various movements of varying pressures to the skin and underlying tissues. The principles behind the use of massage are:

- Varying pressures applied to tissues results in movement of fluid/blood into and out of tissues helping to remove waste and improve circulation.
- By applying pressure in a distal to proximal direction, venous and lymphatic return is encouraged thus helping to reduce swelling and oedema.
- Movements applied to the body result in movement between tissue layers which helps to stimulate the nervous system and loosen adhesions between layers.
- Massage aids relaxation (Sutton, 2004).

Table 2 summarises some of the massage techniques suggested for use in the post-operative period, how they are performed and their proposed benefits.

Passive range of motion (PROM) exercises

PROM exercises involve the physiotherapist moving the joint within, but not beyond, the available range of motion (Millis et al, 2004). *Figure 2* shows a nurse performing flexion on the forelimb joints. This can be repeated a number of times per session, typically 15–20 (Shumway, 2007). Disuse of the limb results in increased stiffness within the joint capsule and changes to the cartilage matrix which make it more susceptible to damage (Millis, 2004a). The purpose of PROM exercises is to maintain range of motion within the joint and improve synovial fluid distribution and removal of waste (Millis et al, 2004). In the case of post-operative rehabilitation after stifle surgery both the stifle and all other joints of the operated limb will be affected by disuse and should be treated with PROM exercises (Kirkby, 2010). Research in humans has found a correlation between the time it takes to regain normal range of motion and the time to full functional recovery, i.e. the faster the patient regains full range of motion the shorter their overall convalescence period (Kirkby, 2010). Shumway (2007) also suggests that if a patient does not receive PROM exercises early in the post-operative period a permanent limited range of motion may result.

Although PROM exercises are essential in the post-operative period to maintain joint capsule and soft tissue flexibility, due to their passive nature they do not prevent atrophy of the musculoskeletal tissues that occurs during limb disuse (Millis et al, 2004). To attenuate the effects of disuse active exercises and weight bearing are required and should be encouraged early in rehabilitation (Millis, 2004a). It is important that exercises are applied in a controlled manner to accelerate healing and not cause injury to healing tissues.

(Image courtesy of Beth Roberts)

Figure 2. Performing flexion on the forelimb joints.

Figure 3. Use of physioball for balancing exercises.

Table 3. Therapeutic exercises

Exercise	How to perform	Progression	Purpose
Controlled leash walking	Walk the patient at a sufficiently slow pace to encourage use of the operated limb (if pace is too fast carriage of the limb is encouraged). A sling may be used initially if the patient is weak and to reduce the chance of falling and injuring healing tissues	Pace can be increased	Encourages weight bearing on the operated limb. Gait re-education
Sit to stand exercises	Use commands/treats to get the patient to move between sit and stand positions. Ensure the patient sits squarely to encourage maximal flexion of stifle joint	Number of repetitions can be increased	Maintains and improves range of motion in hind limb joints. Strengthens hind limb muscle groups (quadriceps, hamstring and gastrocnemius)
Balancing exercises	With the patient in a standing position apply gentle pressure to the hip area to push the patient in the direction of the affected limb. The force applied should be sufficient to cause the patient to temporarily lose balance but not so much that the patient falls over	Perform exercise on an unstable surface or with the front limbs raised off the ground (see *Figure 3*)	Encourages weight bearing on the affected limb. Challenges and improves proprioception and balance. Strengthens hind limb and trunk muscle groups
Dancing	Standing in front of the patient, raise the forelimbs off the ground and move slowly forwards and backwards	Elevation of the front limbs can be increased and the exercise can be performed on an incline	Encourages extension of the stifle. Strengthens hind limb muscle groups. Challenges and improves proprioception and balance
Cavaletti rails	Place a number of poles on the ground at the appropriate distance apart for the patient's stride length, walk the patient slowly over the poles	Poles can be raised off the ground to varying heights, the number of poles can be increased, or alternative poles can be raised	Encourages flexion and extension of joints in the hind limbs (and fore limbs). Challenges proprioception and balance
Weaving	Positions poles vertically at intervals slightly less than the length of the patient's body. Weave the patient in and out of the poles		Challenges proprioception and balance. Strengthens abductor and adductor muscles of the limb

(Hamilton et al, 2004; Saunders, 2007)

Therapeutic exercise

Saunders (2007) discusses how simple re-ambulation is not sufficient to regain strength lost after surgery/injury. Tailored exercises are required to ensure full functional recovery. Therapeutic exercise encompasses a large range of functional tasks used to aid in the rehabilitation of patients, the goals of which include:

- Strengthening muscles
- Encouraging weight bearing
- Improving range of motion
- Improving balance and proprioception
- Cardiovascular and respiratory health (Saunders, 2007).

Table 3 summarises some of the therapeutic exercises that may be used on the post-operative patient after surgery to the stifle. How to perform these exercises, how they can be progressed as the patient improves and the purpose of the individual exercises is also included.

Hydrotherapy

Hydrotherapy is the use of water-based therapy to aid in the rehabilitation of patients. The principles of hydrotherapy and its benefits (as well as contra-indications to therapy) centre on the properties of water and thus the effect of exercising in such an environment. A number of the properties of water and their implications for therapy are described in *Table 4*.

Evidence for the benefit of post-operative physiotherapy in canines

Combination therapy

A number of studies (Millis et al, 1997; Marsolais et al, 2002; Monk et al, 2006) have examined the benefits of a physiotherapy programme, combining several

Table 4. Properties of water and implications for therapy	
Property	**Implications for therapy**
Buoyancy	• Exerts an upward thrust on the body thus reducing weight bearing and facilitating movement towards the surface of the water
Hydrostatic pressure	• Exerts pressure on an object when it is immersed in a body of fluid • Exerts pressure on the tissues and blood/lymph vessels thus aiding lymphatic and venous return resulting in reduced swelling and oedema • Potential contra-indication in cases of respiratory/cardiovascular disease due to increased pressure on the thoracic cavity
Viscosity and drag	• Causes resistance to movement • This allows for greater challenge to the musculoskeletal and cardiovascular systems than the same exercise performed on land • Makes movements in the water slower than that on land aiding standing in weak patients.
Surface tension	• Greater resistance to movement at the surface of the water • Movements at the surface require more energy expenditure
(Becker, 1997; Bockstahler et al, 2004; Monk, 2007; Levine et al, 2010)	

different methods of physiotherapy over a period of weeks post surgery. These approaches mirror what would occur in practice but do not give clear evidence of the benefits of the individual components of the physiotherapy programme, only of the programme as a whole.

Millis et al (1997) undertook a randomised, controlled, preliminary study (ten dogs) looking at the benefits of a physiotherapy programme (PROM exercises, neuromuscular stimulation, active therapeutic exercises and hydrotherapy) over a period of 12 weeks. Improvements were seen in both groups in thigh circumference (muscle mass), range of motion and force plate analysis (limb use) measurements. The physiotherapy group showed significantly ($p<0.05$) greater thigh circumference at week two only and significantly ($p<0.05$) greater extension of the stifle throughout. No other significant differences were seen between groups. Small sample size may have limited the results of this study.

A small study (eight dogs) conducted by Monk et al (2006) over a period of 6 weeks found that treatment with a physiotherapy programme (cryotherapy, PROM exercises, massage, active therapeutic exercise and hydrotherapy) resulted in a significant ($p<0.001$) improvement in thigh circumference and stifle range of motion, compared with a home exercise group. However, weight bearing and lameness scores did not differ significantly between the two treatments. The investigator was not blinded to the treatments therefore subjective scoring methods could have been influenced by the investigator. However, goniometry was used to measure range of motion and this has been shown by Jaegger et al (2002) to be a reliable and objective measurement of range of motion. Conversely, thigh circumference measurement with a tape measure is less standardised with limb position and tape tension affecting results (Millis, 2004b), both of which do not appear to have been considered by the researcher.

Marsolais et al (2002) reported a larger study (51 dogs) which explored the long-term effect (6 months) of a physiotherapy programme (massage, PROM exercises, active therapeutic exercises and hydrotherapy) on the function of the limb after repair of the CCL. This study used measurement of peak vertical force (PVF) and vertical impulse (VI) using force plate analysis to assess the effect of physiotherapy. This method has been used widely in veterinary motion research (Gillette and Angle, 2008) and is a reliable measurement of limb use/weight bearing (Bockstahler et al, 2007; Fanchon and Grandjean, 2009) compared with subjective weight bearing scores, such as that used by Monk et al (2006). This, along with a larger sample size and longer period of study, may account for the results gained by Marsolais et al (2002) which indicated that treatment with a physiotherapy programme, as opposed to a home exercise programme, resulted in significantly ($p<0.05$) greater PVF and VI in the repaired limb. Furthermore, values were no longer significantly different from those of the contralateral unaffected limb.

In studies by Marsolais et al (2002) and Monk et al (2006) the patients were client-owned dogs therefore the level of care provided at home could not be controlled. Additionally, the owners were offered the choice of treatment thus random selection of treatments was not achieved. This could have potentially impinged on results as less conscientious owners, who are less likely to comply with post-operative care instructions, opt out of the more time demanding physiotherapy treatment group.

Key Points

- Post-operative physiotherapy has long been used in humans with vast amounts of research published as to its benefits.
- It has been recognised that changes that occur during immobilisation and disuse of a limb can result in delayed recovery.
- Cryotherapy, heat therapy, massage, passive range of motion exercises, therapeutic exercises and hydrotherapy have all been advocated for use in the rehabilitation of patients following stifle surgery.
- There is minimal evidence on the benefit of these techniques in canines. However, no evidence has shown any negative effect.
- More evidence is required for the benefits of post-operative physiotherapy in canines.

Cryotherapy

A randomised, controlled study conducted by Drygas et al (2011) found that the use of cold compression therapy (CCT) in the immediate post-operative period resulted in reduced pain and increased range of motion in the stifle joint. A significant difference was not seen in thigh circumference (post-operative swelling) though. However, similar research conducted by Rexing et al (2010) found that use of CCT resulted in a reduction in post-operative swelling compared with the use of a bandage. The difference in results could be due to uneven variation in bodyweight and length of surgery between treatment groups in Drygas et al's (2011) study, which occurred despite randomisation. Equally the difference in results could be due to the unreliability of thigh circumference measurements made using a tape measure without a tension device (Millis 2004b), as was used in both studies. Although, research by Baker et al (2010) did find that reliability of measurements could be improved if methods were standardised and measurements taken by the same individual as was done by Rexing et al (2010) and Drygas et al (2011).

Both the studies showed there to be a benefit of cold therapy within the immediate post-operative period. Results presented by Drygas et al (2011) for measurements taken at 14 days post surgery demonstrate no long-term benefit of cold therapy if no further physiotherapy is provided.

Other treatment methods

Currently there is no research to demonstrate the benefit of PROM, massage, therapeutic exercise or hydrotherapy as independent treatments during the post-operative period in dogs suffering from ruptured CCL.

Conclusion

The evidence-base for the use of post-operative physiotherapy in the canine patient is in its infancy. The benefits have been demonstrated in human-based medicine; therefore the lack of animal-based evidence should not deter the veterinary profession from utilising a potentially advantageous complementary therapy. Additionally, in research conducted, no deleterious effect of physiotherapy has been observed. To provide evidence that the benefits recognised in human medicine are truly applicable to the canine patient, further research is required in this field and emphasis should be made to the reliability and validity of such research. As in human practice, post-operative physiotherapy is a dynamic area in veterinary practice and established protocols of best practice will change and develop as more research is conducted. **VN**

Conflict of interest: none.

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